# NASA Handbook 7005: Dynamics Environmental Criteria

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# Overview

- The first version of 7005 handbook was released in 2001 and provides detail information for the following:
  - *The dynamic environments that a spacecraft might be exposed to during its service life from the completion of its manufacture to the completion of its mission.*
  - *The state-of-the-art procedures for predicting the dynamic excitations (loads) produced by the dynamic environments.*
  - *The state-of-the-art procedures for predicting the structural responses to the dynamic excitations.*
  - *The state-of-the-art procedures for establishing dynamic criteria with appropriate margins for the design and testing of a spacecraft and its components.*
  - *The equipment and procedures used to test a spacecraft and its components.*
- The guidelines provided in the handbook do not encompass all the engineering and management details necessary to successfully implement a spacecraft dynamics loads design and verification program.
- A significant revision of the handbook is underway to include new methods and approaches that have been developed within the last 15 years.



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# Modifications Made to Handbook 1/5

The following changes are made to sections in the handbook:

- Section 1:  Updated a few significant breakthroughs in modeling and testing technologies.
- Section 2:  Added a few more references, and a new sub-section on pseudo velocity prediction.
- Section 3: Added the following new sub-sections or provided significant modifications to the exciting sub-sections:
  - *Space vehicle liquid rocket engine green run (new): Discusses the external acoustic environments generation during the launch vehicle model test.*
  - *Flight readiness firing (new): The acoustic environment from FRF must be accounted and designed for.*
  - *Igniter shock environment occurring prior to the ignition overpressure that begins after booster ignition, engine/motor overpressure, engine/motor generated acoustic loads, solid rocket motor pressure oscillations are discussed,*
  - *Multibody, impact and separation (new): Includes liftoff from the pad, stage separation, and spacecraft/launch vehicle separation, parachute flight, docking, and landing.*
  - *Updated references.*


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# Modifications Made to Handbook 2/5

- Section 4: Added the following new sub-sections or made significant modifications to the exciting sub-sections:
  - *Launch vehicle liftoff excitations.*
  - *Spatial correlation.*
  - *Water injection.*
  - *Direct acoustic measurements.*
  - *New section on aeroacoustics predictions that includes new vibro-acoustic modeling methods such as Goody, Efimstov, and Rackl and Weston. These methods are briefly discussed. In addition to these methods the application of the aeroacoustics predictions to Martian atmosphere are also included.*
  - *Some of the discussion related to Statistical Energy Analysis (SEA) are moved to Appendix.*
  - *References are updated.*
- Section 5: Added the following new sub-sections or made significant modifications to the exciting sub-sections:
  - *Low-frequency vibration and transient analysis.*
  - *Norton Thevenin Receptance Coupling method (new):*
  - *Residual vectors and modal truncation (new): Addresses issues associated with truncating normal modes in structural dynamic analysis, at both the system and component level.*
  - *Hydroelastic and sloshing waves in tanks (new): A spring-mass or pendulum modeling is discussed for sloshing waves. A special form of FEM analysis is used for hydroelastic modeling that includes coupling between liquid pressure and tank wall elastic deflection*
  - *Generalized modal shock spectrum procedure, severity equation, and Morse chart:.*
  - *Modal tests:*
  - *High-frequency analysis (new): A detailed discussion of the Coupling Loss Factor Measurement, Damping Loss Factor Theory, Finite Element Method (FEM), Boundary Element Method (BEM), and hybrid methods are provided..*
  - *Structural damping (new): A new section on damping estimate for different forcing functions and structures are briefly discussed in the handbook.*
  - *Updated references.*



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# Modifications Made to Handbook 3/5

- Section 6: Added the following new sub-sections or made significant modifications to the exciting sub-sections:
  - *Envelop limits.*
  - *Normal tolerance limits: an alternative approach is recommended to derive a P95/50 Maximum Predicted Environment (MPE) level.*
  - *Mass loading (new): Asymptotic Impedances, Barrett method, and most recent development in mass loading of flight structures are discussed in this section of the handbook.*
  - *Updated force limited methods: New materials related to this method are included in the handbook.*
  - *Updated references.*



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# Modifications Made to Handbook 4/5

- Section 7: Added the following new sub-sections or made significant modifications to the exciting sub-sections:
  - *Fatigue under random loadings (new):*
  - *Non-Gaussian effects (new):*
  - *Updated references.*
- Section 8: Added the following new sub-sections or made significant modifications to the exciting sub-sections:
  - *Design and test criteria.*
  - *Transient excitation, swept sine excitation, and random vibration excitation*
  - *Modal mass acceleration loads analysis methodology (new):*
  - *Uncertainty Factor*



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# Modifications Made to Handbook 5/5

- Sections 9: Provided an update on shaker technology in this section.
- Section 10: Updated the facilities and procedures used to perform qualification, acceptance, and protoflight dynamic tests on space vehicle hardware that are divided into five categories, namely,
  - *low frequency vibration tests (random and sine),*
  - *low frequency transient tests,*
  - *high frequency vibration tests,*
  - *high frequency transient tests, and*
  - *acoustic tests (DFAT and Reverbrant Acoustic Chamber).*



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# Summary

- A community wide contribution was provided from experts within NASA centers and from the space industry to revise the NASA handbook 7005.
- Many advances made to the discipline over the last several years are included in the revision of the handbook.
- Clarifications are made to some of existing materials to remove misinterpretation often made by some users.
- In this paper the status of the revision of the handbook is provided.
- We anticipate to complete the revision and get it through NASA Agency wide review within the next few months.



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# Thank you

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